

COGNITIVE DETERMINANTS OF RIFLE MARKSMANSHIP

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OVERVIEW

- **The Office of Naval Research (ONR) project**
- **Computer-based assessment in the ONR project**
 - **The USMC Marksmanship application**
- **Conclusions**
- **Next Steps**

THE ONR PROJECT

- **Knowledge, Models and Tools to Improve the Effectiveness of Naval Distance Learning (KMT)**
- **A Human Performance and Assessment Supporting Technology . . .**

of the EQUIP Enabling Capability . . .

of the Capable Manpower Future Naval Capability (FNC)

THE ONR PROJECT

- **The Problem**

- **Assessment models and tools are needed to help Navy, Marine, and contractor personnel evaluate, design and use Distance Learning**

- **Project Goals**

- **Develop and test assessment models and tools on real applications**
 - **USMC marksmanship application**
 - **USN Engineering Duty Officer application**

- **Partners**

- **USC Rossier School of Education**
 - **USC Behavioral Technology Laboratories (BTL)**

USMC MARKSMANSHIP

- **Marksmanship is VERY important**
- **Marines are good, but want to improve**
- **The problem**
 - **In 2002, about 45% of Marines are shooting lower than Expert**
 - **About 2% of Marines are unqualified**
 - **About half need two tries to qualify**
- **The goal: Improve performance, reduce time and cost**

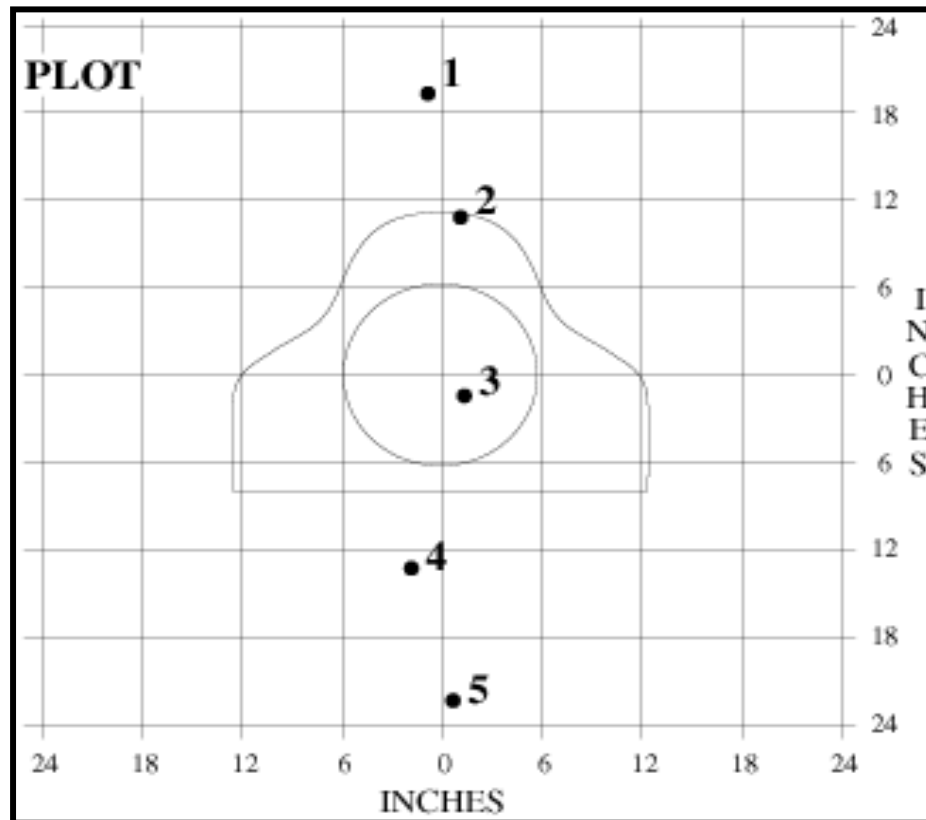
ASSESSMENT IS THE FIRST STEP

- **To improve marksmanship performance and reduce time and cost . . .**
 - **Know what Marines know and don't know**
 - **Then decide how to remediate**

WHAT'S WRONG WITH THIS PICTURE?



AND WHAT WOULD CAUSE THIS SHOT PATTERN?



WHO CARES?

- **The answers are important if you want to be a good marksman**
- **And marksmanship is not easy**
 - **A shooter must routinely hit a 19-inch circular area at 500 yards in the prone position**
 - **A 1/16 inch muzzle deflection will cause a miss of over 2 feet at 500 yards**

500 YARDS

1.5 times the distance between the top rows of opposite end zones of the LA Coliseum



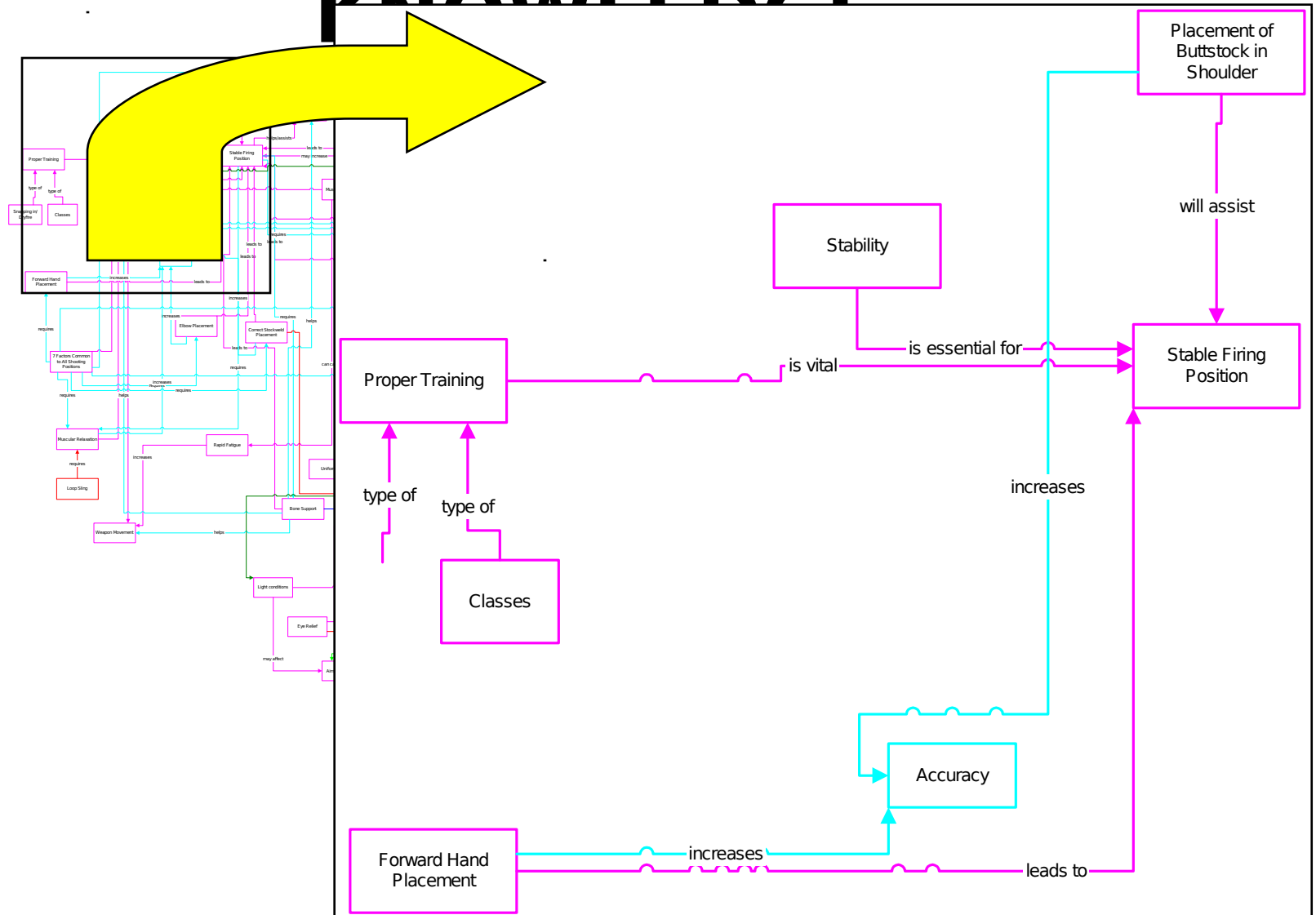
THE PLAN

- **Identify potential unqualified Marines before they reach the firing line—on-line—using CRESST assessments of marksmanship knowledge—the cognitive determinants**
- **Research Questions**
 - **What are the critical types of knowledge that affect shooting performance?**
 - **To what extent can cognitively-based measures predict USMC rifle shooting performance?**
 - **To what extent can cognitively-based measures be used to prescribe effective remediation?**

THE COGNITIVE DETERMINANTS OF RIFLE MARKSMANSHIP

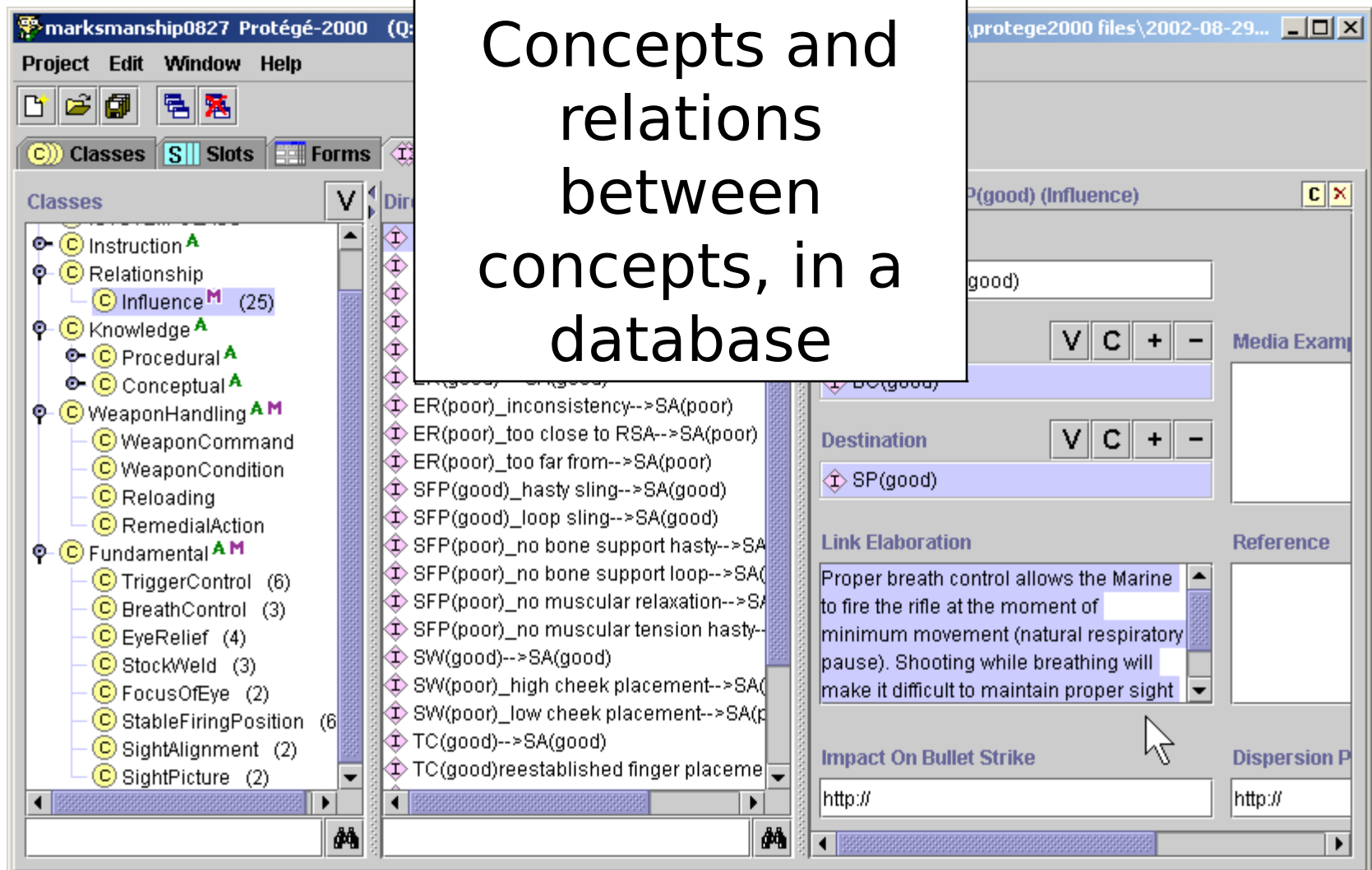
- **Shooters need to know the fundamentals of rifle marksmanship**
 - **What each fundamental concept is**
 - **Trigger control, breath control, eye relief, stock weld . . .**
 - **How it's related to other concepts**
 - **How it affects shot placement**
- **Shooters need to be able to apply knowledge of fundamentals to identify and correct problems**

MARKSMANSHIP KNOWLEDGE



MARKSMANSHIP KNOWLEDGE BASE: AN ONTOLOGY

Concepts and
relations
between
concepts, in a
database



USMC MARKSMANSHIP

To what extent can cognitively-based measures predict USMC rifle shooting performance?

MARKSMANSHIP ASSESSMENTS

- **Marksmanship inventory knowledge assessment**
- **Knowledge mapper**
 - **Fundamentals**
 - **Shot-to-shot**
 - **Data book procedure**
 - **Shot group depiction**
- **Evaluation of shooting positions**

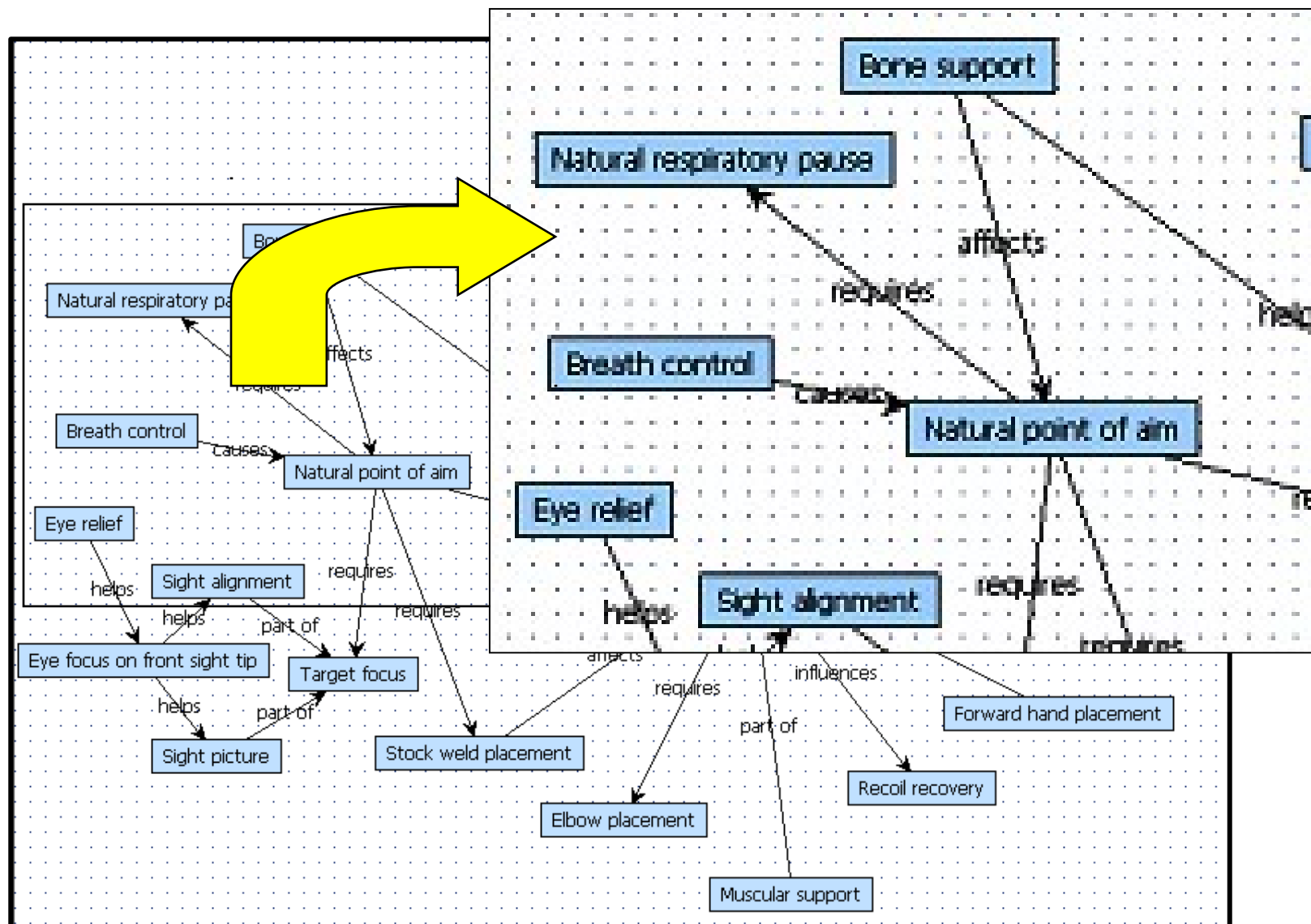
MARKSMANSHIP INVENTORY KNOWLEDGE ASSESSMENT

- **Short answer, multiple-choice**
- **Evaluates prior experience, knowledge, affect**
- **Most recent qualification score**
- **Prior knowledge of marksmanship**
- **Trait and state firing line experience—worry and anxiety about qualification**

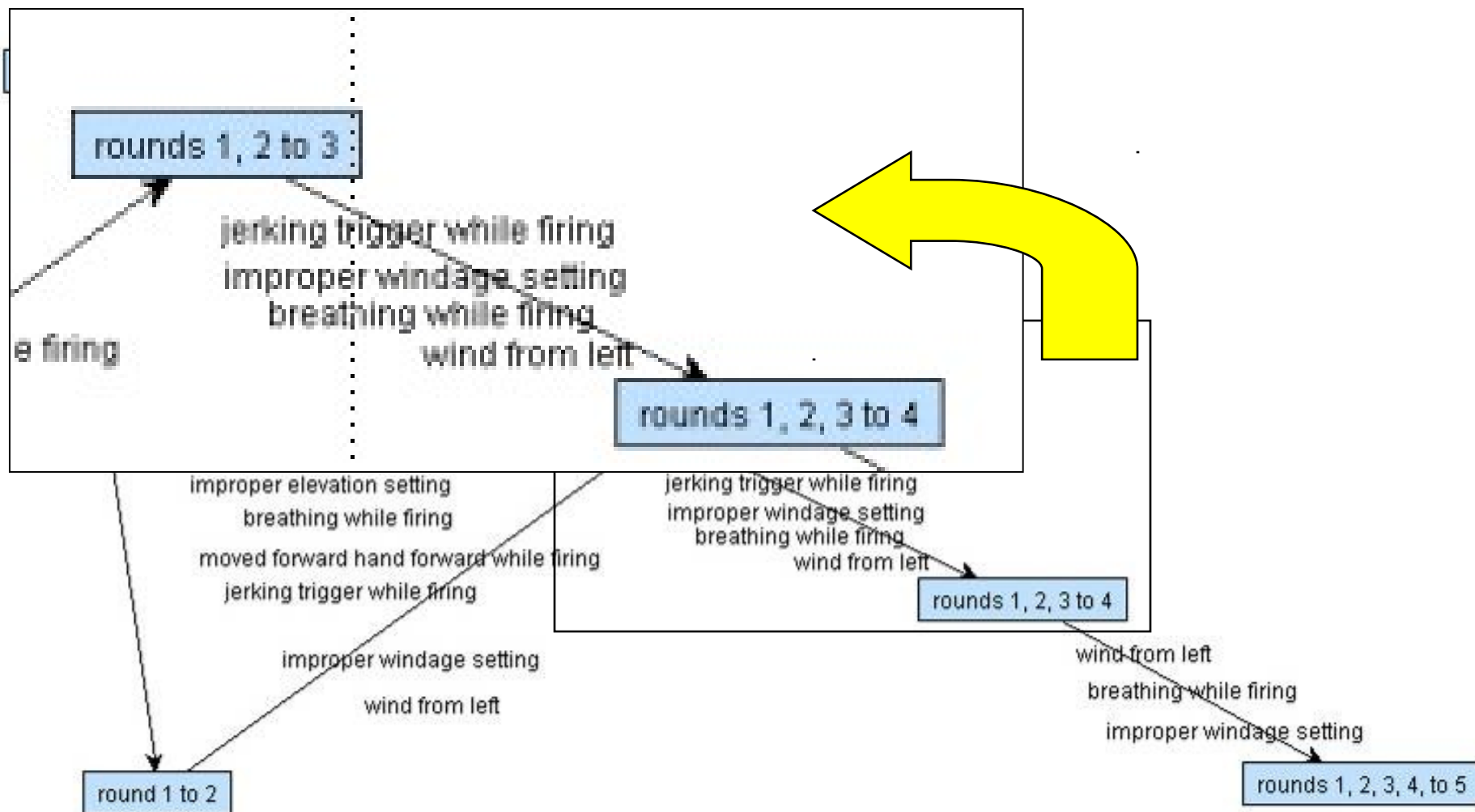
MARKSMANSHIP KNOWLEDGE MAPPER

- **Trainees diagram key marksmanship concepts and relationships**
 - **Fundamentals**
 - **Shot-to-shot explanation**
 - **Data book procedure**
 - **Shot group depiction**
- **Score against a “doctrine” map**

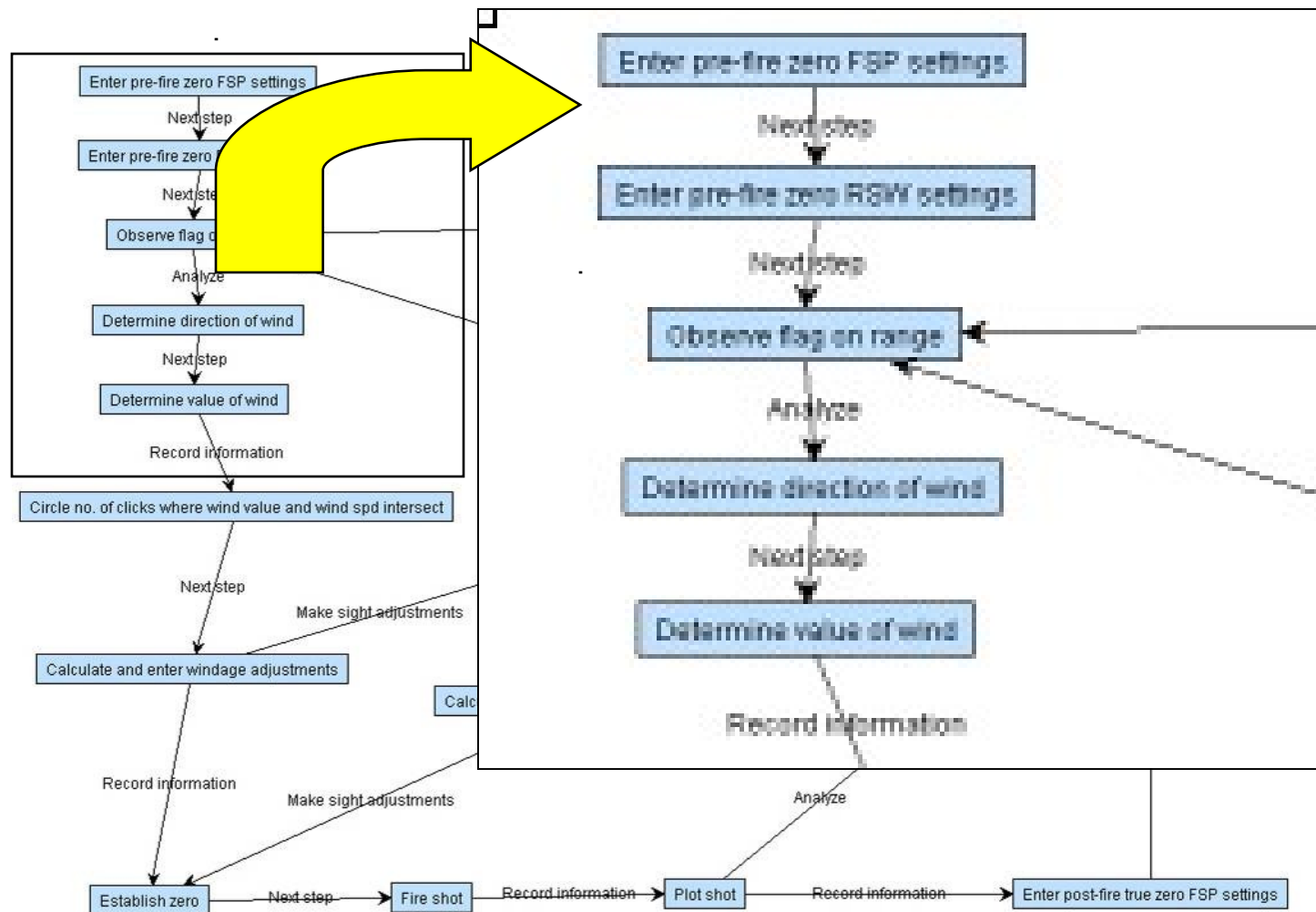
MAPPER: FUNDAMENTALS



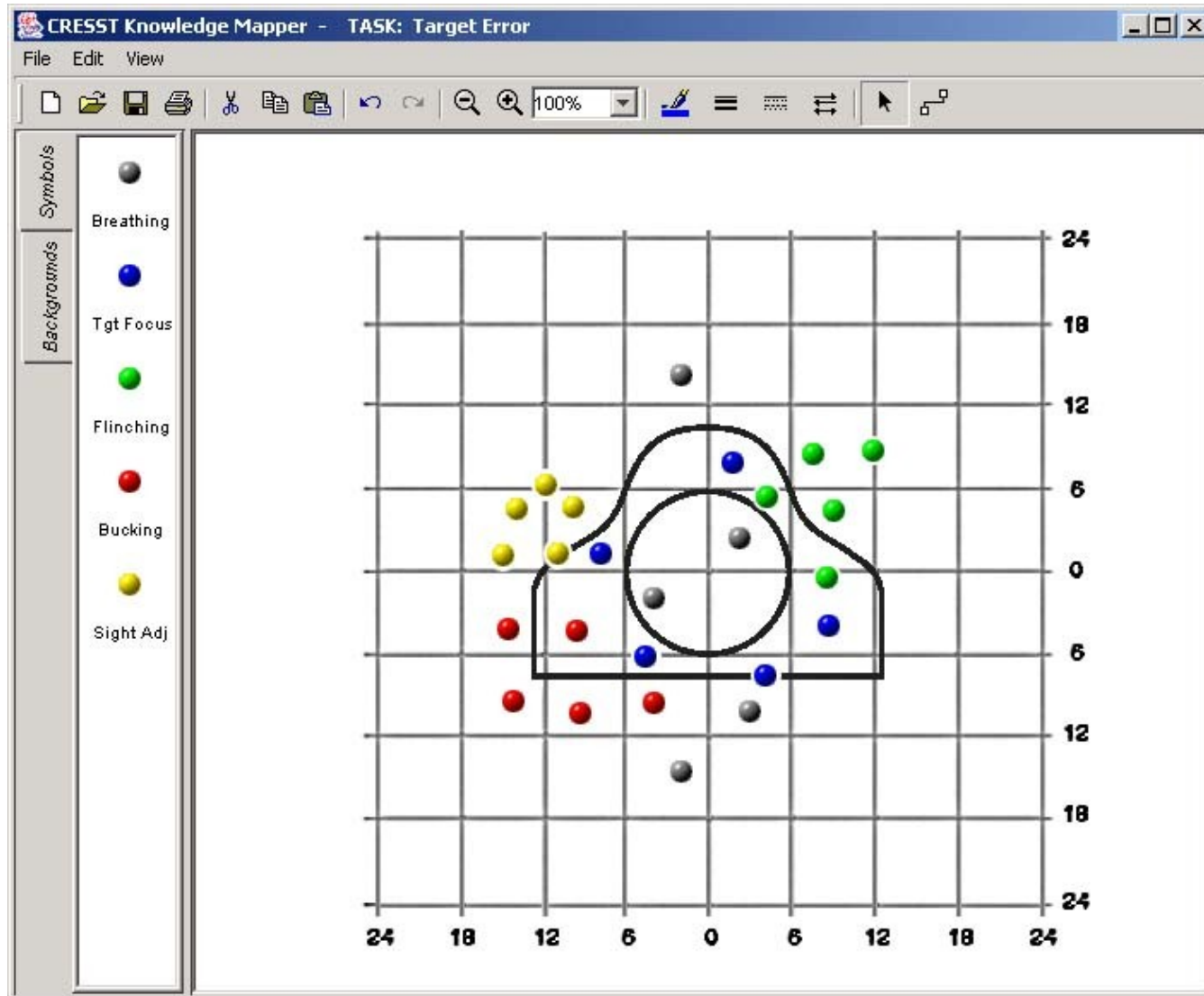
MAPPER: SHOT-TO-SHOT



MAPPER: DATA BOOK PROCEDURE



SHOT GROUP DEPICTION



EVALUATION OF SHOOTING POSITIONS

- **Assess and correct fundamental problems with shooter's body position and the resulting impact on performance**

EVALUATION OF SHOOTING POSITIONS

The screenshot shows the 'Assessment of Rifle marksmanship Skills' software interface. The main window has a blue header with the CRESST logo and the text 'Advanced Distributed Learning Program'. Below the header, there is a video player showing a soldier in a prone position. To the right of the video player is a table for evaluating shooting skills. A large black arrow points from the 'proper' column of the table to the video player.

	proper	improper	
1300			
Eye Relief	<input type="radio"/>	<input checked="" type="radio"/>	correct >>
Placement of Firing Hand	<input type="radio"/>	<input type="radio"/>	
Elbow Placement	<input type="radio"/>	<input type="radio"/>	
Stock Weld	<input type="radio"/>	<input type="radio"/>	correct >>
Rifle Butt	<input type="radio"/>	<input type="radio"/>	
Leg Placement	<input type="radio"/>	<input type="radio"/>	
Feet Placement	<input type="radio"/>	<input type="radio"/>	
Body Alignment	<input type="radio"/>	<input type="radio"/>	

MODEL OF SKILL ACQUISITION

- **Three phases of skill acquisition (Ackerman, 1987, 1992; Fitts & Posner, 1967; Wrisberg, 2003)**
 - **Cognitive: instruction most effective, frequent errors, inconsistent performance**
 - **Associative: integrate parts of the process, errors gradually eliminated**
 - **Autonomous: process becomes automatic, less moderated by cognition**
- **Predict cognitive variables more important in beginning, cognitive phase**

SAMPLE AND METHOD

- **Sample**
 - **Over 200 Marines**
 - **Two locations**
 - **Varying prior experience**
- **Method**
 - **Regress cognitive and affective measures against shooting scores**

RESULTS

To what extent can cognitively-based measures predict USMC rifle shooting performance?

- **Multiple Rs ranged from .52 to .80**
- **Cognitive and prior experience variables are important predictors in less experienced shooters**
- **Prior experience more important than cognitive variables in more experienced shooters**
- **Affective variables important at all levels of experience**
- **Quality of measures**
 - **Appear sensitive to instruction and knowledge differences**
 - **Increase in knowledge scores over instruction, coaches course sample score much higher**

USMC MARKSMANSHIP

To what extent can cognitively-based measures be used to prescribe effective remediation?

LINKING ASSESSMENT AND INSTRUCTION

- **Requirements**
 - **Need a way to represent the domain**
 - **Use an ontology**
 - **Need a way to estimate what someone knows about a domain given performance data on assessments**
 - **Use Bayesian networks to fuse assessment data and infer understanding of domain and topics within domain**

LINKING ASSESSMENT AND INSTRUCTION

**Bayesian Network
Model of Knowledge
Dependencies**

**Ontology of
Marksmanship
Domain**

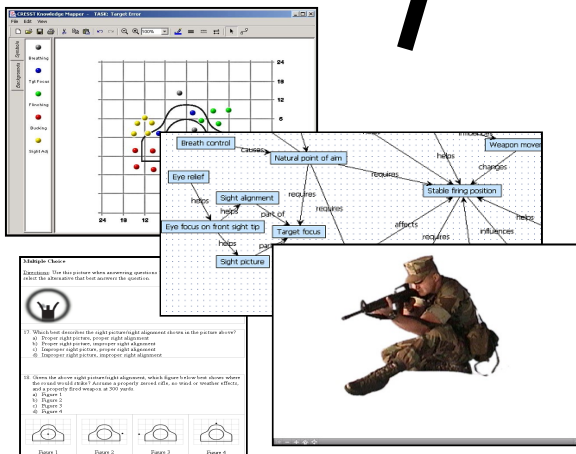
item-level scores

probability of
knowing/ not
knowing content

content

Recommender

individualized
feedback and
content



6015	Score on Topic (0-10)	Stock Weld Placement
Topics		
Bone Support	10	
Breath Control	7	
Forward Elbow Placement	10	
Eye Relief	10	
Forward Hand Placement	8	
Sight Alignment	8	
Sight Picture	9	
Stock Weld Placement	3	
Trigger Control	1	
Trigger Squeeze	6	

Definition
Stock weld is the point of firm contact between the cheek and the stock of the rifle.

Concept
A consistent and proper stock weld is critical to the aiming process because it provides consistency in eye relief, which affects the ability to align the sights. Changing the placement of the cheek up or down on the stock from shot to shot may affect the zero on the rifle due to the perception of the rear sight aperture. If the position of the Marine's head causes him to look across the bridge of his nose or out from under his eyebrow, the eye will be strained. The eye functions best in its natural forward position.

The head should be as erect as possible to enable the aiming eye to look straight through the rear sight aperture. A firm contact between the cheek and the stock enables consistent eye relief and enables the head and rifle to recoil as a single unit. Stock weld provides recovery between rapid fire shots, keeps the aiming eye centered in the rear sight aperture and prevents the head from bouncing off the stock during recoil.

Pictures
stock_weld1
stock_weld2

Videos
stock_weld
stock_weld
stock_weld

FEEDBACK AND CONTENT DELIVERY

6015	Score on Topic (0-10)
Bone Support	10
Breath Control	7
Forward Elbow Placement	10
Eye Relief	10
Forward Hand Placement	8
Grip of Firing Hand	4
Natural Respiratory Pause	4
Sight Alignment	8
Sight Picture	9
Stock Weld Placement	3
Trigger Control	1
Trigger Squeeze	6

Stock Weld Placement

- Definition**

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- Concept**

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- Pictures**

[stock_weld1](#)
[stock_weld2](#)
- Videos**

[stock_weld](#)
[StockWeld](#)
[StockWeld](#)

Local intranet



STUDY SAMPLE AND DESIGN

- **Sample**
 - **USMC 2nd Lts. undergoing entry-level marksmanship training**
- **Design**
 - **Experimental condition: Receive individualized feedback and content delivery**
 - **Control condition: No intervention**
 - **Pretest, posttest measures of knowledge**

PROCEDURE

- **Day 1: Administer knowledge pretests**
- **Day 2: Report scores on different topics and provide access to individualized content**
- **Day 10: Administer knowledge posttests**

RESULTS

To what extent can cognitively-based measures be used to prescribe effective remediation?

- **Individualized instruction appears to have increased conceptual knowledge**
 - Performance on targeted concepts improved in the experimental group
 - No change in the control group
- **Bayesian network appears to be capturing the knowledge dependencies**
 - Similar to Marines' self-assessments
 - Correlated with shooting scores

NEXT STEPS

- **Planning to field tools for use in the Coaches Course, USMC Weapons Training Battalion**
- **New ONR work on cognitive determinants of psychomotor skills, focusing on performer background and elite performers**
- **New ONR work on assessments for diagnosis and prescription using ontologies and Bayesian networks, tested in the marksmanship domain**

THE TAKE-AWAY MESSAGE

- **ONR science and technology can support USMC marksmanship training**
- **Assessments of knowledge of the fundamentals of rifle marksmanship can be used to predict USMC rifle marksmanship performance for cognitive-stage performers**
- **There is suggestive evidence assessments of knowledge of the fundamentals of rifle marksmanship can be used to prescribe effective remediation**

FOR MORE INFORMATION

<http://www.cse.ucla.edu>

or any search engine: type CRESST

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